TECHNOLOGY ACCESS AND ADOPTION POLICY

CONSIDERATIONS

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EXECUTIVE SUMMARY

During the past nine years the International Development Research Centre (IDRC) has supported a series of projects concerning Technology Adoption by Small and Medium Scale Enterprises (SMEs) under the mandate of the Technology and Local Enterprises Program (TLEP) of the Earth and Engineering Sciences Division (EESD). These research projects, conducted on a collaborative basis, have joined two research teams from Canada (University of Saskatchewan and Saskatchewan Research Council) with cooperating organizations from three countries, Malaysia, Singapore and Thailand, to examine the technology needs of SMEs, review alternative models of technology transfer processes and to develop models of linkages among technology developers, technology users and technology disseminators.

A review and evaluation of these projects has been carried out previously (90-2028). The present study is to provide some guidance for policy setting regarding future IDRC activities concerning Science and Technology Policy and should be seen as a continuation of the previous evaluation.

The present project objective was to provide recommendations whether or not an IDRC program with similar objectives to TLEP should continue to support research in the area of Science and Technology, particularly "Technology Adoption" and if so, what modifications should be made to the approach which has been followed in the past.

The original projects obtained results which met the stated objectives with emphasis on data gathering and the tabulation of SME needs to develop profiles. It is considered that many SME needs and problems can be defined and classified as common to all, regardless of where they exist, with specific needs dependent upon the uniqueness of the industrial sub-sectors, infrastructural requirements and particular cultural differences between regions. In addition, that in general technology program delivery should be delivered through existing public and private support institutions by continually monitoring and responding to SME needs, improving capabilities and delivery mechanisms.

Of the active fields of research pertaining to S&T policy, there are four broad areas that are most relevant for lesser developed economies. These are:

- Methods of identifying, addressing and supporting human resources needs for firms, technology support institutions, government and the private sector and in particular management training needs;

- The proper mix and type of funding mechanisms to support SME technology access and adoption;

- The design and development of effective technology diffusion mechanisms for sectoral and firm-level technological upgrading;

- The nature of processes and relevant management information to spur SME interest in technological development.

In this context, it is recommended that in the restructuring of IDRC programs, research opportunity areas exist in developing more effective ways of assessing the effectiveness of science and technological infrastructure, as it is the key, linking network between producers and users of technology. Examination of existing technology transfer infrastructures can lead to a greater understanding of the operational mechanisms of technology transfer, the barriers and stimulants inherent to the process, and possibly to new and innovative approaches to successful transfer operations. IDRC focus may include research in examining infrastructure weaknesses and strengths, and support development efforts to ensure targeted approach to projects which address weak links in the process. In addition, IDRC may build on previous project experience and significant Canadian expertise in the areas of technology diffusion and adoption, with emphasis on policies to support government development assistance programs for the lesser developed countries, principally through S&T institutions.

OVERVIEW OF THE PROJECT

During the past nine years the International Development Research Centre (IDRC) has funded a series of projects concerning Technology Adoption by Small and Medium Scale Enterprises (SMEs) under the mandate of the Technology and Local Enterprises Program (TLEP) of the Earth and Engineering Sciences Division (EESD). These research projects, conducted on a collaborative basis, have joined two research teams from Canada (University of Saskatchewan and Saskatchewan Research Council) with cooperating organizations from three countries, Malaysia, Singapore and Thailand, to examine the technology needs of SMEs, review alternative models of technology transfer processes and to develop models of linkages among technology developers, technology users and technology disseminators.

A review and evaluation of these projects has been carried out previously (90-2028). The present study is to provide some guidance for policy setting regarding future IDRC activities concerning Science and Technology Policy and should be seen as a continuation of the previous evaluation.

PROJECT OBJECTIVE

To recommend whether or not the Technology for Local Enterprises (TLEP), or a program with similar objectives under IDRC structure, should continue to support research in the area of Science and Technology, particularly "Technology Adoption", and if so, what modifications should be made to the approach which has been followed in the past.

CONSULTING ASSIGNMENT AND METHODOLOGY

The consulting assignment in view of the mandate and prospectus of IDRC, is to identify the field of activity or "niche" within Science and Technology Policy which does not receive appropriate attention, which, if filled would create in IDRC an area of innovation. The work includes consideration of the previous specific project results concerning the Technology Adoption by Small and Medium-Sized Enterprises (SMEs) projects funded by IDRC and a review of existing literature and programs regarding institutional technology based support activities for SMEs.

Specific tasks include the preparation of a report which provides conclusions and recommendations regarding the following:

A. Within all active fields of research pertaining to Science and Technology Policy, which fields are most relevant (in terms of potential impact of research results) to SMEs in developing countries?

1. At what stage of development do SMEs in a country generally become interested in Science and Technology Policy issues? What are the research opportunities in this field in lesser developed countries, such as in Sub-Saharan Africa, or poorer countries in Asia?

2. What is presently known regarding the types of industries which are most likely to benefit directly from this type of research, if results are applied:

   a. "High tech" or "low tech" industries?

   b. Industries where rapid technological advances are occurring, or those where there has been little recent technological change?

c. Labour-intensive or capital-intensive industries?

d. Small- or medium-scale industries or the informal sector?

3. Which other donor agencies have had the most successful results related to this field?

B. In view of the mandate and prospectus of IDRC, identify the field of activity within Science and Technology Policy which does not receive appropriate attention. In other words, identify a "niche" which, if filled, would create in IDRC an area of innovation.

C. Make specific recommendations as to how this "niche" should be dealt with by an IDRC program which aims to increase income and employment generated by small- and medium-scale enterprises in developing countries, including the following:

1. Should the niche area and/or other Science and Technology Policy issues be addressed:

a. As a separate and independent subject of inquiry, with projects entirely devoted to policy questions, or

b. As a component of each project, much as is done now for the socio-economic analysis or local participation.

2. Potential Partners:

   a. Who (donor agencies, public or private institutions) could work with IDRC in funding these types of research?

   b. Who are the experts in this field which we could call upon to work with us? Which Canadian research institutions are most advanced in this field? Are there opportunities for South-South collaboration?

OVERVIEW AND ASSESSMENT OF SCIENCE AND TECHNOLOGY NEEDS IN A DEVELOPING ECONOMY

Small and Medium-Sized Enterprises are the foundation of industrial economies and, as in all economies, SMEs in Developing economies do not operate on a common production function. Technological knowledge is not shared equally among firms, nor is it easily imitated by or transferred across firms. While it is recognized that the major factor in commercially based technology movement is the multinational corporation (MNC) the role of training and education cannot be underestimated as the role of "people" constitutes the most valuable aspect of science and technology development and upgrading.

Raising the quality of working life and increasing output have now become major preoccupations of governments in many debeloping countries. The usual approach taken by the developing countries towardw achieving these goals is through the acquisition of technology from the more industrialized countries. However, a good number of factors need to be considered when introducing new technology of developing countries. They include (1) the infrastructure and economic status of the nation; (2) working conditions; (3) social and cultural differences; and (4) matching of technology and users. Although the same technological principles may apply to both industrialized and developing

countries, the practices and problems tend to differ. Advancement of new technology is acknowledged as an important step towards maximal economic output, with intensive automation replacing human labour. In developing countries, however, any implementation of new technology requires technical support. Many developing countries have poor infrastructure and face a shortage of basic facilities. When technology is to be transferred, due account has to be taken of the economic and technical status of the developing countries. With the introduction of new technology, traditional work methods may have to be changed. This evolution may give rise to cultural conflict as the individual has to learn to adapt to his or her new lifestyle and values while at the same time struggling to retain his or her cultural heritage.

In the developing countries context, it is assumed that major innovations all occur in the advanced industrial countries and that developing countries select and costlessly apply those innovations that are useful or appropriate. As the general level of capital accumulation (and skills) rises, more capital-intensive (or complex) technologies become economical. These are also bought from the technology shelf.

Large multi national or internationally engaged firms are a major source of technology and have become key transfer agents, and they tend to prefer direct foreign-investment as the method of transfer. In many instances, the transferred technologies were designed for large markets which have an abundance of capital and high-level labour skills. In the developing countries, these conditions often do not prevail since markets are small, and capital and skills are scarce. Thus economic theory suggests that these firms should adapt their techniques when investing in developing countries and should use much less capital per man than they do in advanced countries.

FIRM LEVEL TECHNOLOGICAL DEVELOPMENT

At the firm level, transfer of technology necessarily requires learning. To gain mastery of a new technology requires skills, effort and investment by the receiving firm, and the extent of mastery achieved is uncertain and varies by firm according to these inputs. The extent to which firm-level differences in technological effort and mastery occur will vary by industry, by size of firm or market, by level of development, or by trade/industrial strategies.

Firm-level technological change is a continuous process to absorb or create technical knowledge, determined partly by external inputs and partly by past accumulation of skills and knowledge, with an innovative component to support all types of search and improvement efforts. From the firms' point of view, there is little difference between efforts to improve technological mastery, to adapt technology to new conditions, to improve it slightly or to improve it very significantly - though in terms of detailed strategies, degrees of risk and potential rewards, these efforts will certainly be different.

There are various ways to categorize firm-level technological capabilities. - (TABLE I)

Table 1. *Illustrative matrix of technological capabilities*

DEGREE OF COMPLEXITY			FUNCTIONAL					
			INVESTMENT		PRODUCTION			
			PRE INVESTMENT	PROJECT EXECUTION	PROCESS ENGINEERING	PRODUCT ENGINEERING	INDUSTRIAL ENGINEERING	LINKAGES WITHIN ECONOMY
	BASIC	SIMPLE, ROUTINE (Experience based)	Prefeasibility and feasibility studies, site selection, scheduling of investment	Civil construction, ancillary services, equipment erection, commissioning	Debugging, balancing, quality control preventive maintenance, assimilation of process technology	Assimilation of product design, minor adaptation to market needs	Work flow, scheduling, time-motion studies. Inventory control	Local procurement of goods and services, information exchange with suppliers
	INTERMED-	ADAPTIVE DUPLICATIVE (Search based)	Search for technology source. Negotiation of contracts. Bargaining suitable terms. Info. systems	Equipment procurement, detailed engineering, training and recruitment of skilled personnel	Equipment stretching, process adaptation and cost saving, licensing new technology	Product quality improvement, licensing and assimilating new imported product technology	Monitoring productivity, improved coordination	Technology transfer of local suppliers, coordinated design, S&T links
	ADVANCED	INNOVATIVE RISKY (Research based)		Basic process design. Equipment design and supply	In-house process innovation, basic research	In-house product innovation, basic research		Turnkey capability, cooperative R&D, licensing own technology to others

While the functions set out in TABLE I may not be exhaustive, there is a basic core of functions in each category that need to be internalized by the firm to ensure successful commercial operation. The very nature of technological learning (i.e. accumulated experience of problem solving, aided by external inputs or formal research efforts) would seem to dictate that mastery would proceed from simpler to more difficult activities. Different firms and different technologies adopt different sequences.

If a firm is unable by itself to decide on its investment plans or selection of equipment processes, or to reach minimum levels of operating efficiency, quality control, equipment maintenance or cost improvement, or to adapt its product designs to changing market conditions, or to establish effective linkages with reliable suppliers, it is unlikely to be able to compete effectively in open markets. Moreover, the basic core must grow over time as the firm undertakes more complex tasks. The ability to identify a firm's scope for efficient specialization in technological activities, to extend and deepen these with experience and effort, and to draw selectively on others to complement its own capabilities, is the hallmark of a "technologically mature" firm. Before full "maturity" is achieved, firms will vary in their mastery of the various functions involved. While this is true of any economy, it is likely that the typical firm in developing countries, with deficiencies in skills and limited experience of manufacturing, will use the same technology less efficiently than its counterpart in developed countries. Scattered evidence confirms that this is in fact the case, and that such differences also exist between more and less advanced developing countries. (Pack, 1988).

INVESTMENT CAPABILITIES AND LINKAGE

Investment capabilities are the skills needed to identify, prepare, obtain technology for, design, construct, equip, staff, and commission a new facility)or expansion). They determine the capital costs of the project, the appropriateness of the scale, product mix, technology and equipment selected, and the understanding gained by the operating firm of the basic technologies involved (which, in turn, affect the efficiency with which it later operates the facility). *Production capabilities* range from basic skills such as quality control, operation, and maintenance, to more advanced ones such as adaptation, improvement or equipment "stretching," to the most demanding ones of research, design, and innovation. They cover both process and product technologies, as well as the monitoring and control functions included under industrial engineering. The skills involved determine not only how well given technologies are operated and improved, but also how well in-house efforts are utilized to absorb technologies bought or imitated from other firms (on the significance of research and development for assimilating external innovations see Cohen and Levinthal, 1989). *Linkage capabilities* are the skills needed to transmit information, skills and technology to, and receive them from, component or raw material suppliers, subcontractors, consultants, service firms, and technology institutions. Such linkages affect not only the productive efficiency of the enterprise (allowing it to specialize more fully) but also the diffusion of technology through the economy and the deepening of the industrial structure, both essential to industrial development. The significance of extramarket linkages in promoting productivity increase is well recognized in the literature on developed countries. (For references see the survey by Cohen and Levin, 1989, and for an empirical test, Cohen and Levinthal, 1989. The last chapter of Lall, 1985, develops and applies the linkage concept in a developed setting.)[1]

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[1]*World Development,* Vol. 20, No. 3, 1992, Printed in Great Britain, p.168.

The main influences on the demand side for firm-level technological capability includes:

- an inherent need for the development of new skills and information simply to get a new technology into production. This necessity operates regardless of policy regime and provides the elemental drive for firms to invest in capability building; the form that capability building takes depends on the nature of the technology (process or batch, simple or complex, large to small scale);[2]

- an inherent pressure for capability acquisition with external pressures (e.g. competitive pressures, trade regimes, a stable high-growth environment);

- Technological change itself which proceeds continuously in almost all industries in the developed world stimulating developing countries' firms to try to keep up.

On the supply side, the ability of firms to produce capabilities depends on:

- the size of firm (where technologies are complex and call for large-scale production, large amounts of skilled labour or intense technological effort and particularly where capital markets are deficient);

- access to skills from the market;

- organizational and managerial skills in the firm and its ability to change structures to absorb new methods and technologies (Hoffman, 1989; Katz, 1987);

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[2]*World Development.*, p. 168.

- access to external technical information and support (from foreign technology sources, local firms and consultants, and the technology infrastructure of laboratories, testing facilities, standards institutions and so on); and

- access to appropriate "embodied" technology, in the form of capital goods, from the best available sources, domestic or foreign.[3]

TECHNOLOGY AND INFORMATION NEEDS OF SMEs

Many small and medium industrial enterprises operate with very short-term planning and they are market-oriented only to a limited degree.

Problems related to break-down of machinery and equipment, difficulties in the management process, complaints from clients concerning the quality and reliability of products or the quality and workability of raw materials, etc., are well known and very often require immediate action.

Too many enterprises rely exclusively on the advice of suppliers; while such advice may be good, managers cannot ascertain that it is.

Any enterprise operating exclusively as a subcontractor to larger and often too few industrial clients is in just the same position.

It becomes too dependent on information, skills and expertise that are the proprietary rights of other people.

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[3] *World Development.*, p. 169.

Another type of vulnerable position is found in cases of transfer of technology, when the receiver has not reached the appropriate level of professional competence and independent qualifications through the organized acquisition of technological information.

It is important for small and medium enterprises to realize that the basic elements of the industrial process are:

a. Knowledge of the market

b. Design of the products

c. Manufacturing of the products

d. Marketing, selling and servicing the products

e. Controlling and measuring the products, processes and performances of the enterprise

f. Evaluating current achievements with a view to the elaboration of a future strategy

g. Acquiring appropriate and relevant technological information for improvement and innovation.

The success of an industrial enterprise is largely due to the capacity of its managerial and other staff to reflect of their observations and to ask the right questions.[4]

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[4] *The Small and Medium Industrial Enterprises and Technological Information Services / Concepts, Insights and Experiences*, prepared by the Committee on Engineering Information of the World Federation of Engineering Organizations, Sept. 1981, p.6.

RESEARCH AND DEVELOPMENT NEEDS OF SMEs

The research and development needs of SMEs cover a broad range of service and technology development functions. Inherent in this need is access to trained, competent human resources offering multidisciplinary hands-on support and ready access to information and specialized facilities. This support can be provided through public institutions or private sector companies as the conditions dictate, however in the case of lesser developed countries, public sector sources provide the major pools of available resources.

There are three technology-based development issues that are particularly appropriate for developing countries:

- The creation of new enterprises to serve unmet needs of local and related export markets. — Help establish new enterprises to meet domestic needs that are currently not being met by local industry.

- The improvement of the competitiveness of current industry in present markets. — Help present enterprises improve their quality and reduce their manufacturing costs through adoption of new processing technologies and methods. For example, computer-assisted manufacturing technologies might be adopted by small firms to reduce set-up time and increase production quality.

- The development of new capabilities within the current industrial structure. — Help present enterprises add new capabilities to their products and expand their markets through integration of new technologies.

Specific research and service support requirements for SMEs include:

Research support

- Raw material identification and testing
- Product development, testing, quality control and standardization
- Research into appropriate technologies
- Assessment and priorization of needs and opportunities
- Information needs - state of the art searches
- Contract research

Service support

Human resource development

- special and short term courses
- traditional courses
- continuing education
- entrepreneurial training
- management

Consulting

- feasibility report preparation
- accounting
- marketing

Socio-economic support

- evaluation and assessment
- study of impact of technologies
- techno-economic studies

Technology contracts

- negotiations
- contract drafting

Finance support

- dissemination of sources and types of finance
- special programmes

Other service support

- dissemination of research results
- extension services
- promotional needs[5]

Specific research and service support requirements include:

Human Resource Development

- management training
- entrepreneurship
- special courses
- continuing education

A. MAJOR RESEARCH OPPORTUNITIES

Of the active fields of research pertaining to S&T policy, there are four broad areas that are most relevant for lesser developed economies. These are:

a) Methods of identifying, addressing and supporting human resources needs for firms, technology support institutions, government and the private sector and in particular management training needs;

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[5] *University-Productive Sector Linkages: Review of State-of-the-Art in Africa,* prepared by M. N. B. Ayiku for the Association of African Universities, 1990, pp. viii - ix.

b) The proper mix and type of funding mechanisms to support SME technology access and adoption;

c) The design and development of effective technology diffusion mechanisms for sectoral and firm-level technological upgrading;

d) The nature of processes and relevant management information to spur SME interest in technological development.

POTENTIAL RESEARCH ACTIVITIES

1) The development of effective systems to support technology upgrading in SMEs to improve competitiveness, including the development of effective multidisciplinary firm-level extension services, directly linked with capability of supplying basic laboratory and testing facilities, technical information services, with problem-solving and product development capabilities;

2) The development of linkages between government departments and agencies and providers of extension services;

3) The provision at firm-level of relevant, easy-to access technical information services in conjunction with appropriate firm-level professional interpretation and support;

4) The relationship of subsidized government sponsored services to private sector providers of the same services;

5) The extent to which services are provided by large corporations for their suppliers;

6) Human resource and training requirements to deliver effective firm-level, in-plant assistance programs;

7) Financial programs to support SME research needs for problem solving, firm-level upgrading, new product development, and training;

8) Program promotion and program design to develop face-to-face, on site (in-plant) delivery processes to ensure pro-active programs;

9) The availability and directed use of adequate financial resources to support technology-based programs by delivery and support organizations;

10) The development of joint industry/government sectoral training programs or demonstration projects;

11) The inter-linkage of technology-based support institutions, government programs, and industry;

12) The development of supplier programs for SMEs as sub-contractors for larger companies or government;

13) The development of awareness, within industry sectors and at firm level, of the need to acquire and effectively use technology;

14) Firm-level skills upgrading (management, technical, supervisory, business, etc.) to support technology management (i.e. acquisition, adoption, adaption, development and/or use);

15) The development of qualified locally-based consultants to meet local requirements;

16) The organizing of industry cooperatives, associations and industry sector groups to support individual SME development;

17) Methods of acquiring or developing technologies suitable to the country's stage of development.

SME INTEREST IN POLICY

In the lesser developed countries, while the needs are many, the stage of development dictates that efforts be directed to developing new companies, supporting sectoral priorities and acquiring technology. The firm-level needs of companies, while broad, are ongoing, consistent and part of a continuum of development which varies only in the level of specific type of technology or technological requirement (skills) at a certain stage of growth. This is to some degree a function of the sophistication of the firm as represented by its owner/manager, availability of resources and the desire to improve enterprise performance.

Stage of interest:

Generally SMEs become interested in policy issues when informal or formal organizations are formed which can represent them within forums or when government policies stifle growth.

S&T POLICY ISSUES FOR SMEs

SMEs are owned and managed by individuals who are most concerned about company survival and driven by day to day requirements of production and serving customer needs. This by nature with the daily demands on time and energy results in very limited effort dedicated to longterm planning or a broad view of national S&T policy issues. Interest is generally driven by self-need (problems of competition, government policies, etc.) and/or incentive. This indicates that in the early stages of development in a lesser developed region when growth rates are high there is incentive inherent in the market opportunity, in addition through intervention governments attempt to build technological capacity in selected sectors. The complex interplay of factors of incentive structures and market driven incentives that determines at the firm level how well producers learn the skills and master the information needed to cope with industrial technologies.

RESEARCH BENEFITS TO INDUSTRY

The development of pro-active, responsive technology diffusion systems can provide extension services which are relevant to SMEs at various stages of development including "high tech" or "low tech" industries or industries where rapid technological advances are occurring or industries seeing little recent change.

The basis for an effective system in effect provides a delivery system at firm-level having:

- face to face advisory services;
- multi disciplinary human resources;
- delivered through the public sector institutions;
- direct access to industrial information systems;
- direct access to technical support facilities, e.g. laboratories, product development resources;

- direct linkage to public and private sector technology support institutions, organizations and companies;
- access and knowledge of project funding programs and/or financial support sources.

For early stage informal-sector, "low tech", or labour-intensive industries having limited in-house technical capability, effective technology adoption support requires intensive hands-on activity, from knowledgable individuals working at firm-level to provide and interpret information and make it available in a usable form for management. This is often followed by active participation in implementation and training (hand-holding).

In "high tech", capital intensive or industries experiencing rapid technological change there is generally a higher level of technological capacity within the company with highly trained or skilled technical people on staff. Support for technology adoption is more often provided on the basis of supplying information either directly or through networks relying on the company to interpret needs and identify resources and specialized skills required. Extension services may fill the role of information support, consultation, referral or project support (problem solving, product support, specialized consulting).

DONOR AGENCY RESULTS

While it is difficult to judge the relative success of donor agencies with regard to support for research activities in technology adoption processes, the efforts made by USAID, World Bank and European groups (eg. Danish, German) have provided valuable contributions to improving assistance efforts in this regard. An in-depth analysis of the large amount of sponsored literature and programs which presently exist would entail a significant additional time committment.

B. NICHE OPPORTUNITY FOR IDRC

The effectiveness of the scientific and technological infrastructure is possibly the most critical element in any technology transfer operation as it is the key linking network between the producers and users of technology. The infrastructure, or delivery system, functions to bring perceived or articulated user needs to the attention of funders and research producers, and in turn delivers research results or technology to meet stated user requirements. Examination of existing technology transfer infrastructures can lead to a greater understanding of the operational mechanisms of technology transfer, the barriers and stimulants inherent to the process, and possibly to new and innovative approaches to successful transfer operations. IDRC focus will include research in examining infrastructure weaknesses and strengths, and support development efforts to ensure targeted approach to projects which address weak links in the process. In addition, IDRC may build on previous project experience and significant Canadian expertise in the areas of technology diffusion and adoption, with emphasis on policies to support government development assistance programs for the lesser developed countries, principally through S&T institutions.

Research considerations will include:

- In industrialized nations the intranational transfer of technology generally follows a clearly prescribed path, involving a set of clearly defined participants;

- Well-developed infrastructures contain a relatively complex network of paths and participants which generally remain subservient to the function of the overall network;

- The technology transfer process must be viewed as containing essentially all the same elements generally associated with industrial development; if any of these are lacking in any given transfer operation, its chances for success are markedly reduced;

- The linker or broker role appears key to the effective function of a technology transfer infrastructure;

- The aggressive development of a strong intranational infrastructure within a developing nation could be anticipated to impact significantly and positively on the rate of industrialization and economic growth;

- Examination of the goals of the particular program (at all levels);

- Measuring the effectiveness of user contact;

- Determination of the effectiveness of communication patterns;

- Examination of specific case histories;

- Determining the degree to which stated goals are met.

C. SPECIFIC RECOMMENDATIONS FOR IDRC

In developing nations the transfer of most commercial technology is accomplished through multinational corporations. There is no doubt that the transfer of this technology has both positive and negative consequences; however it is felt that the positive consequences outweigh the negative. The negative criticisms suggest that managers of SMEs must have a high degree of involvement in determining the type of technology to be imported and used in the implementation process.

Identifying the appropriate technology to import is a difficult task for user enterprises in developing countries. It has been found that managers in developing countries tend to lack the ability to identify and apply the technologies necessary to solve their problems; there is a need for new programs that will enable developing firms, through stronger management skills, to use existing information on technology and apply available technologies to their operation.

Through linkages and firm-level support systems, managers can acquire a greater understanding of how to implement new technologies. A problem which many managers face is that new technology is often restricted. That is, managers often encounter problems in implementing new ideas.

The most effective way of designing and implementing research programs includes, not only funding and development of research papers and subsequent publication and presentation of results, but practical follow-on activities of assessing alternatives, designing and implementing projects. IDRC programs should be designed to test theory, encourage participation, and disseminate results by way of demonstration projects.

The niche area broadly described in terms of infrastructure considerations may focus on the following:

- willingness of the transferer and the transferee in technology transfer activities;
- the role of effective R&D or S&T programs;
- the role of education and training system for human resources development;
- the proper planning and firm level support to acquire appropriate technologies.

The niche area should be addressed as a component of all projects although specific projects could be launched on a country-by-country basis. This suggests that appropriate technology adoption systems can be developed to provide firm-level support for the benefit of SMEs resulting in increased levels of income and employment.

Potential partners for funding this type of research may include:

- Asian Development Bank
- Inter American Development Bank
- Organization of American States
- World Bank
- U.S. Agency for International Development
- United Nations Industry Support Organizations (UNIDO, UNCTAD, UNDP)
- Various European Organizations (SAREC, EUROTECH, the Commonwealth Secretariat)
- Canadian International Development Agency
- National Research Council of Canada

Within Canada the organizations having the most experience and expertise in working with SMEs include:

- National Research Council (IRAP)
- Provincial Research Organizations or The Technology Network (APRO) comprised of eight separate organizations
- Selected University based researchers and consultants (U of Toronto, U of Saskatchewan)

Opportunities for South-South collaboration exist centered in industrial research organizations and universities. In the least developed nations, expertise exists primarily in educational institutions or government departments, agencies or multi national corporations.

APPENDICES

APPENDIX 1

Factors Fostering Technology Transfer

• Arriving at a clear understanding of the needs, perceived and real of the target user	Lingwood 1975 Roberts and Frohman 1978
• Proximity of recipient to source	Miller and Cote 1985
• Presence of agents of change	Rogers 1982
• Inclusion of technology transfer criteria in personnel selection	Essoglou 1980
• Newsletter where innovations are reported	Greathead 1980
• Support of the process by top management	Hertz 1965
• University - industry relationship that is relatively open (*vs* Japan and Europe)	Moss 1983
• Characteristics of recipient organization:	Carter and Williams 1959
High quality of incoming communication	
A readiness to look outside the firm for technology	
A willingness to share knowledge	
A willingness to take on new knowledge, to licence and to enter joint ventures	
Effective internal communication and coordination mechanisms	
A deliberate survey of potential ideas	
An awareness of costs and profits in the research and development departments	
Identification of the outcomes of investment decisions	
Use of management techniques	
High status of science and technology of the firm	

Use of scientists and technologists on the Board of Directors	
A high rate of expansion	
Good quality intermediate management	
High quality of chief executives	
• Perception of need by recipient	Langrish *et al.* 1972
• Recognized market potential	Myers and Marquis 1969
• Proximity of recipient to institutions of higher education - particularly research institutions	Glazer 1986
• Third-party brokering systems	Meima *et al.* 1984
• Recognized need in the production process	Myers and Marquis 1969
• Contextual mapping-dialogue between source and target	Bradbury *et al.*1978
• Research universities with policies encouraging faculty involvement with firms	Rogers 1986
• Need recognition (demand pull)	Utterback 1974
• Identification of recipient and collaborator relationship as early as possible in the transfer process	Park 1982
• Appropriate legislation	Brody 1985 McDermott 1985
• Source anticipation of user requirements	Jervis 1978
• Favourable and uniformly applied Federal policies	Baldwin 1986
• Recipient motivation	Sharif and Haq 1980 Kotlenstete and Rusnak 1973 Rothwell 1978
• New cost-effective techniques for distance-learning	Eldridge 1984 Reynolds 1982
• Source self-monitoring of output quality and marketing style	Essoglou 1980

• Trust and goodwill between source and recipient organizations	Shelp *et al.* 1984
• Patents	Elsasser 1977
• Functioning at about 75% of operating capacity	Mansfield 1971
• Faculty consulting	Howsam 1985
• University related research parks	Glazer 1986
• Firms' access to university resources	Azaroff 1982 Brown 1985
• Recipient affiliation with a university	Smith 1984
• The transfer of knowledgeable people	Bradbury *et al.* 1978
• Perceived reward	Nyenhuis and Welborn 1976
• Communication between research institutions and industry	Allen 1973 Johnston 1976
• Technology transfer consultants	Goldscheider 1982
• Use of technology audit	Goldscheider 1982
• Use of technology assessor	Nasbitt and Kline 1987
• Clearing house	Goldscheider 1982 Ohio Board of Regents 1982
• Use of distance-spanning technology	Shelp *et al.* 1984[6]

[6]Godkin, Prof. Lynn, (1988) "Problems and practicalities of technology transfer: a survey of the literature", *Int. J. Technology Management*, Vol. 3 No. 5, pp. 595 - 596.

APPENDIX 2

Factors Hindering Technology Transfer

• Industry often lacks the will or ability to specify the nature and appropriateness of research	Monroe and Irvins 1982
• Language barrier limits the amount of information that can be imported from abroad	Brown 1985
• Most research related to technology transfer is retrospective	Bell and Hill 1978
• There is little longitudinal study of technology transfer	Bell and Hill 1978
• There is scarce observation of the technology transfer process while in progress - it may be misunderstood	Bell and Hill 1978
• Fear of intra-firm linkages by host country	Garland and Farmer 1986
• The view that a technology can be specified in a replicable way	Bradbury *et al.* 1978
• Underestimation of the problem of transferring technology to less developed countries	Bradbury *et al.* 1978
• Foreign recipients of technology are imposing far stricter conditions on its transfer than earlier	Garland and Farmer 1986
• Explicit appreciation of the important role technology can play in the economic development of Third World countries has only recently emerged	Frame 1986
• Desire by less developed countries to throw off dependency on the North and to establish their own identity	Goldscheider 1982

• Belief of leaders of developing countries that decisions affecting their economies are being made by foreigners	Voll 1980
• Bureaucratic delays with foreign countries instituted by individuals or groups unknowledgeable about technology transfer	Goldscheider 1982
• Patents having 'human value' remain unused because assurance of profits cannot be guaranteed	*The Economist* 1987
• Government intervention and regulation	Abernathy and Chakravarthy 1979
• Training of recipient is lacking	Knox 1973
• Published findings of diffusion have not been well analysed from a managerial perspective	Talaysum 1985
• The innovation process is relatively costly and inefficient	Tushman 1979
• Promotion of licensing activity, especially by large international firms	Bradbury *et al.* 1978
• Information storage and retrieval systems	Lickider 1966 Bradbury *et al.* 1978
• 'Taxation Effect'	Millar 1978
• Host countries worried about control	Voll 1980
• Institutional structure for innovation or innovation-initiating capabilities not in place	Bell and Hill 1978
• The suitability of a technology for a developing country	Voll 1980
• The transmission channels	Voll 1980
• The cost of technology	Voll 1980
• Inadequate laws protecting intellectual property in other countries	Frame 1986
• The capacity of the developing country to absorb the technology	Voll 1980

• Organizational (non-technical) factors	Tushman 1979
• Uncontrollable market factors	Myers and Sweezy 1978
• Limited sales potential	Myers and Sweezy 1978
• Poor management	Myers and Sweezy 1978
• 'Two cultures' - the scientific and the literary	Snow 1976 Declercq 1981
• Absence of key people with necessary skills	Roberts and Frohman 1978
• Customer fails to see value of change as worth the cost	Roberts and Frohman 1978
• System developed in the West mistrusted by emergent nations	Chung 1984
• Promotion of licensing activity, especially by multinationsl corporations, may lead to transfer of inappropriate technology	Bradbury *et al.* 1978
• Rapacious licensing, abuse of tax systems, and other factors have led even those countries most in need of Western technology to set up controls making technology transfer difficult	Millar 1978
• Lack of incentive for invention disclosure between federal agencies and federal laboratories	Meima *et al.* 1984
• Limited ability of federal agencies to track R&D developments in federal laboratories	Meima *et al.* 1984
• Limited ablity of federal agencies to maintain positive working relationships with programme administrators and key researchers in federal laboratories	Meima *et al.* 1984
• Limited ability of federal agencies to identify secondary utilization potential for R&D from federal laboratories	Meima *et al.* 1984

• Application assessment routes followed by various technologies developed in federal laboratories vary from agency to agency before reaching patent stage	Meima *et al.* 1984
• Inadequate reviews of commercial criteria when federal agency patent decisions are made	Meima *et al.* 1984
• Lack of an appropriate model for commercial evaluation of government inventions	Meima *et al.* 1984
• Research teams not interdisciplinary in nature	Lingwood 1975
• R&D-to-client ratio	Lingwood 1975
• Unfamiliarity with client needs	Lingwood 1975
• A shortage of technology transfer managers	Gartner and Naiman 1978
• Cultural and social differences between source and recipient	Kim 1984
• Lack of clear market definition and familiarity	Roberts and Frohman 1978
• Project was initiated by the wrong person	Goldscheider 1982
• Technology transfer alters or destroys pre-existing values	Goulet 1977
• Failure to reward applications	Essoglou 1985 Lingwood 1975
• Failure to reward long-range projects	Lingwood 1975
• Individual or organizational competition	Essoglou 1985
• Those outside of R&D not rewarded for seeking innovation	Lingwood 1975
• Turnover among key people knowledgeable of target organization	Lingwood 1975
• Misjudgements made during solution identification phase	Jolly 1980
• Mismatched value orientation of R&D and operations personnel	Essoglou 1980

• Failure of management to identify liaison personnel to act as linking pins between source and recipient	Battenbur 1980
• Use of scientists to promote technology who do not have necessary communication skills	Bradbury *et al.* 1978
• Organizational initiatives involving introduction of innovative technology into the organization not rewarded[7]	Essoglou 1985

[7]Godkin Prof. Lynn, (1988) 'Problems and practicalities of technology transfer: a survey of the literature', *Int J. Technology Management*, Vol 3, No. 5, pp. 596 - 598.